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ABSTRACT

It can reasonably be argued that the primary role of elementary teachers is to prepare their students to be literate adults, and thus many are literacy specialists. Often these teachers lack confidence in science and avoid it because it is not their specialty. Most elementary teachers have never conducted a scientific inquiry, yet they are being asked to teach science as inquiry. Though an action research project is not the same as a scientific inquiry, it can still provide an experience similar to scientific inquiry for teachers. Therefore, an appropriate strategy for fulfilling both a need to engage in inquiry and a need for professional development in science teaching would be to prepare teachers to use action or teacher research in their teaching practice. This paper describes the action research projects completed as part of a Masters in Teaching two-year program. The projects focus on investigating a specific teaching strategy or approach. (Contains 31 references.) (Author/MVL)

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by
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THE ELEMENTARY SCIENCE TEACHER AS RESEARCHER

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Overview

Elementary teachers are usually generalists, without specialty or special preparation in either science content or pedagogy. It can reasonably be argued that their primary role is to prepare their students to be literate adults, and thus, many are literacy specialists. Oftentimes elementary teachers may lack confidence in teaching science (Cox & Carpenter, 1989; Perkes, 1975; Tilgner, 1990) and thus avoid science because it is not their specialty (Atwater, Gardener, & Kight, 1991; Schoeneberger & Russell, 1986). Most elementary teachers have never conducted a scientific inquiry, yet they are being asked to teach science as inquiry (Kielborn & Gilmer, 1999). Even elementary teachers who are confident in their science backgrounds and teaching approaches could benefit from conducting an inquiry project, and could improve their teaching practice with systematic study. Though an action research project is not the same as a scientific inquiry, it can still provide an experience similar to scientific inquiry for the teachers. Thus, an appropriate strategy for fulfilling both a need to engage in inquiry, and a need for professional development in science teaching would be to prepare teachers to use action, or teacher research, in their teaching practice.

Inquiry

The *National Science Education Standards* (NRC, 1996, 2000) recommend that all science teachers continue to develop their pedagogy and content knowledge through inquiry. Inquiry is defined as raising an investigable question, developing methods to answer that question, carrying out those methods, analyzing the data, and reporting findings and making

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conclusions. It has been traditionally thought of as difficult to prepare elementary teachers to use inquiry methods to teach science, partially because they may have limited science backgrounds, and likely no experience in conducting scientific inquiry (Kielborn & Gilmer, 1999).

Giving K-8 teachers experiences with scientific inquiry has been shown to improve their understandings of inquiry, hopefully relating to their abilities to teach using inquiry to their own students (Kielborn & Gilmer, 1999). Additionally, learning in context is important, (Putnam & Borko, 2000; Saxe, 1988), and thus, using research on one's own teaching can provide a personal context for inquiry.

Teacher Development

There have been recommendations to support elementary teachers in professional development for both pedagogy and content for teaching science (National Commission on Science and Mathematics Teaching for the 21st Century [The Glenn Commission Report], 2000; NRC, 1996). Oftentimes teachers receive materials or textbooks to use for science instruction, but no guidance in their effective use. Just getting materials does not guarantee an improvement in teaching. Rather, it is the professional development that helps teachers effectively use the materials that can create an improvement in teaching. However, not all curricula, materials, or strategies are equally effective for all teachers, grade levels, and student groups. What can teachers do to improve their own science teaching in their teaching setting? One appropriate strategy is for teachers to conduct action research projects to actually test a teaching strategy, materials, or curricula, with their students, to track the effectiveness of the strategy. The action research project allows the teachers to note under which circumstances and with which students a new strategy is most effective. It enables the teachers to have data supported reasons for using particular strategies, and it shows the teachers, through the data and evidence collected, how

effective new strategies can be for student learning. Teachers can make changes in their own teaching, and use data to support the implementation of those changes.

Teacher Research

What is teacher, or action, research? Simply put, it is when the classroom teacher conducts research on her own teaching or teaching situation. Feldman and Minstrell (2000) describe action research as teachers inquiring into their teaching in their classrooms. The teacher systematically designs a study, collects data, analyzes the data, and interprets and reports the results, a process that parallels scientific inquiry. In fact, it can be defined as inquiry into one's own teaching. The study can be used to inform teaching practice, and develops a reflective practitioner (Hubbard & Power, 1993). One of our preservice teachers aptly summarized her understanding of action research based on her experiences:

> You are doing something [in the classroom] and then you are asking yourself "Does this really work?" And you are not relying on intuition to say, "Well, it felt like it kind of worked." You're actually looking for evidence to say "Does this work?"...So, [in action research] you are going a step further than just a visual kind of thing, an emotional kind of thing, you are looking for evidence.

Schon (1983) recommends that practitioners in any field become reflective to be aware of, and to improve their practice. Indeed, in teacher education with the emergence of programs based on a constructivist perspective for learning, a central goal of many programs has been developing reflective practitioners (Christensen, 1996; McIntyre, Byrd, & Fox, 1996). Through reflection teachers have the opportunity to build their own knowledge about their practice from their own experiences. It has been shown that classroom-based action research promotes reflection on action for preservice teachers (Valli, 2000). Elementary teachers can become more reflective of their science teaching and base deliberate instructional decisions on data (Roth McDuffie, 2001).

Some might suggest that elementary science teachers could get the same benefits in development of teaching practice from reading other's research reports. Reading others' research is beneficial, but not solely helpful at delineating practices that would work best for individual teachers. Scott and Driver (1997) found that while researchers may be able to conduct research in someone else's classroom, it is difficult to interpret the results, and make recommendations for teaching strategies because the researcher does not know the students as well as the teacher. However, by using a teacher research approach the teacher is able to decide which approaches are best for students. Other elementary teachers and elementary teacher educators have made similar improvements in their science teaching from using reflective teacher research (e.g. Akerson, Abd-El-Khalick, & Lederman, 2000; Dickinson, Burns, Hagen, & Locker, 1997). Indeed, several studies have pointed to the importance of action, or teacher research, in developing preservice teacher abilities to reflect on, and improve their own teaching, particularly in the field of science, with the support of a university researcher (Chandler, 1999; Fueyo & Neves, 1995; Scott, 1994; Stanulis & Jeffers, 1995; van Zee, 1998; Winograd & Evans, 1995). Feldman and Minstrell (2000) described a lengthy process through which one teacher developed a teacher research agenda and the ability to conduct action research to improve his teaching of science. The teacher claimed that action research became a natural part of his teaching over time, allowing him to track his effectiveness and influence on students while he is teaching.

There is evidence that elementary teachers need experience in inquiry (Kielborn & Gilmer, 1999) and in professional development for teaching science (i.e.. Atwater, Gardener, & Kight, 1991). Action research promises to give teachers an authentic experience in inquiry on their own science teaching as a professional development tool. Thus, it is recommended that

teachers learn to use action research as both an approach to inquiry as well as a tool for professional development in science teaching.

Methods for Preparing Elementary Teachers to Use Action Research

Our students completed an action research project as part of a Master in Teaching (MIT) program. This two-year masters degree program served preservice teachers who already held a baccalaureate degree in a field other than education and desired to become teachers. Two primary objectives of this program were: "(1) To educate teachers to become effective practitioners who…by bringing the inquiry method of a research university to bear on the entire educational process… (2) To empower teachers as reflective practitioners by helping them develop the multiple and critical decision making skills essential for today's classrooms" (University program description document). This research-based approach to developing reflective practitioners was evident in the design of the student teaching internship. Requirements of the internship included: twelve weeks in a K-8 school placement, solo teaching for at least 4 weeks; writing in a reflective journal at least once each week; completing a goals sheet at least once each week (identifying a goal for their teaching and reflecting on their success in meeting that goal); writing lesson plans for all lessons taught; developing a unit plan; completing at least four focused observations of teachers' teaching and writing a report on each observation; and completing a classroom-based action research project on their teaching.

Regarding the action research project, the preservice teachers designed their studies during the previous semester as part of a course titled "Classroom Focused Research," taught by the first author. Using two texts as a framework for study (Hubbard & Power, 1993; McNiff, Lomax, & Whitehead, 1996), the preservice teachers studied methods of designing and conducting action research, and planned original classroom-based research projects as part of

this course. The action research project focused on investigating a specific teaching strategy or approach. Preservice teachers were encouraged to select a teaching strategy and content area about which they felt least secure, and in which they wanted to improve their teaching. Each preservice teacher worked with a faculty committee consisting of a chair (with expertise in the preservice teacher's selected area for research) and two additional faculty members from the Department of Teaching and Learning. The preservice teachers wrote literature reviews in their areas of study as part of a full study proposal. These proposals were submitted to the preservice teachers' chairs for feedback and reviewed three times during the semester before submitting a final version at the end of the semester. They implemented their studies the following semester during student teaching. In the month after their student teaching internship the preservice teachers analyzed their data, wrote and presented oral and written reports of their studies to their faculty committee.

Research Support and Results of Elementary Science Teachers Using Action Research as Professional Development

After preparing four groups of preservice teachers to conduct their own action research projects in their internship settings, we have experienced many of the students' frustrations and successes. Interestingly enough, the frustrations are present predominantly in the design of the study. Preservice teachers began with a negative attitude toward conducting teacher research, similar to the negative attitudes with which they often come to the science methods classroom. To be sure, there were still frustrations while in the field conducting the research, analyzing the data, and writing up the research. Most felt quite overwhelmed at the idea of conducting action research in combination with the already challenging activities of student teaching. For example,

one student summarized her feelings of both seeing the benefit of action research and also feeling a bit anxious about it when she said,

> I know that it's beneficial because it's really going to force us to plan what we are doing. And to look at a specific area of interest to us. And to work on developing it…, but it is daunting, definitely! It's hard to know how data collection will fit in with normal teaching.

Reassuring the preservice teachers that they indeed, can do both concurrently, and that the research can support their development as a teacher, is crucial. One suggestion that has worked for us is to invite a previous student, now in the classroom, to share their research as well as experience conducting that research during their internship experiences. It is inevitable that the previous student will share that the work is difficult, but worthwhile in their professional development.

The preservice teachers generally had difficulty thinking of a researchable question, tending to have a question that is too broad, such as comparisons of several teaching strategies over a four-week period, or that was focused on something extrinsic to the development of their own teaching practice, such as playing background music while students work to see that effect. However, with support from the course instructor, and each student's individual discipline chair, feasible designs that focus on teaching strategies were completed, and the preservice teachers then implemented these in their internships.

When the preservice teachers completed writing their final reports of their action research was where the successes really shine. They were excited to share their new-found, data based knowledge. It was evident from their animated presentations that they were excited about their results, and were anxious to share their information with others. Many chose to also present their work at a University-wide Research Symposium, competing with all disciplines. In fact, in two of the last three years of the symposium, top prizes were awarded to education student projects,

which was a wonderful feat given the judges are multidisciplinary and the students were competing against the hard sciences as well as social science studies. Many of the science action research projects have also been presented at national conferences (Akins & Akerson, 2000; Baker & Roth McDuffie, 2000; Bohrmann & Akerson, 2001; Burke & Akerson, 2002; Dickinson & Reinkens, 1997; Jardine and Roth McDuffie, 2001; Kelso & Akerson, 2000; Liu & Akerson, 2001; Nguyen & Roth McDuffie, 2001; Nixon & Akerson, 2002; Pringle & Dickinson, 1999; Stine & Akerson, 2001; Wright & Dickinson, 1999;) Additionally, one preservice teacher's work has been published in a peer reviewed journal (Bohrmann & Akerson, 2001), two are in press in peer reviewed journals (Akerson & Reinkens, 2001; Liu & Akerson, 2002) and another is under review (Akins & Akerson, 2001). Undergoing the extra work required to present a paper at a national level, as well as submit and publish a paper in a peer-reviewed journal speaks volumes to the value these preservice teachers placed on their work. Nonetheless, they needed support in these endeavors, and it is unlikely that any would have pursued disseminating their work to a wider audience were it not for support from a university researcher. It is also the case that these preservice teachers would be unlikely to initially engage in action research and attempt different approaches to teaching and learning were it not for being required to do so, and being supported by the university researchers. A student spoke directly to this issue when she said:

> [Another preservice teacher] and I were talking on the phone the other day, and she said "Wouldn't it be easier if we didn't have to do the research projects?" And I said, "Yeah, you know, I had thought about that too. It would have been a lot easier." And then…I realized that it pushed me out of that comfort zone, at least in [the one area I was researching]. Where if I didn't have that requirement I would not have worked at incorporating new ideas in teaching. I asked her, "Do you think you would have done what you did in [innovative teaching] if you hadn't done the research project?" And she said, "No!" So if nothing else, it pushes us out, at least in one content area, out of our comfort zone [to try something different].

One preservice teacher stated that "including action research is the difference between just working and being a professional." Another stated, "I hate to admit it, but doing the action research project forced me to test teaching methods I may not have otherwise tried. And it made me think about what I was doing."

Thus, we have found evidence that action research has helped with the professional development in science teaching of our preservice teachers. It has also given them an authentic, meaningful, contextualized inquiry experience.

Recommendations for Including Action Research in Elementary Science Teacher Development

We have had successful experiences in using action research for elementary science teacher development. The teachers with whom we have worked have received professional development opportunities as they research, in their own classrooms, how strategies for teaching science work with their students. Additionally, these teachers have experienced an authentic inquiry project. While not the same as a scientific inquiry, the process parallels what scientists do, particularly social scientists, and gives them a model of inquiry they may choose to have their students use.

From our experience in using action research to help preservice elementary science teachers both improve their teaching of science and undertake an authentic inquiry experience, we have six recommendations. These recommendations include (a) emphasize that preservice teachers focus on a meaningful, researchable question that focuses on their teaching practice, (b) encourage preservice teachers to select areas for research about which they are least familiar, (c) provide university support for the preservice teachers throughout all phases of the project, (d) focus preservice teachers on a stringent research design, (e) encourage students to realize they

can conduct the research project, and (f) encourage preservice teachers to disseminate the results of their studies.

First, preservice teachers should select a research question that is meaningful to them, and that focuses on their teaching practice. If the requirement to focus on teaching practice is not there, then the preservice teachers may choose a research question that is not conducive to professional development. For instance, preservice teachers could select a project that studies the effects of natural light on student science performance. While this could, in theory, be argued to be a valuable study, it would not lend itself to professional development of science teachers. Thus, preservice teachers should focus on designing studies that focus on development of their science teaching, such as using conceptual change teaching strategies to promote student learning, or exploring interdisciplinary approaches to teaching science.

If preservice teachers could choose to study any teaching strategy or content area they wish, they would often select a literacy focus. Yet they often need the most professional development in areas they would not choose to study, such as science. It is for this reason that we recommend encouraging preservice teachers to design studies that can help them improve their teaching of subjects for which they feel the least confident. Once they implement teaching strategies, and collect and analyze data attesting to the effectiveness of the strategy, they may feel more comfortable about using it, and teaching that content area. They will, at the very least, have more experience in teaching that content area than they would if they had conducted a literacy study.

Third, university faculty should work closely with preservice teachers throughout the entire process of designing the studies, data collection and analysis, and writing. Regular feedback during each phase is essential for students new to research. Helping preservice teachers

design viable, meaningful studies, as well as collect and analyze the data, is very important. As part of this process, university faculty need to encourage students to think carefully about the implications of their findings. Often students report findings and end their research report without interpreting these findings for their own practice and for others' practices. For example, in Nixon and Akerson (2002) the preservice teacher originally concluded her paper with the result that her elementary students' interpretations of their own science investigations became more superficial when constrained by various writing forms in her attempt to investigate how science can influence language arts skills. When asked to think about interpreting this result, she realized that while science and language arts can be thought of as interdisciplinary at times, there are still times where disciplinary instruction is most appropriate in each. Appropriate disciplinary instruction allows for appropriate development in each discipline, and for teachers to help students to meet each discipline's objectives. Without prompting from her university mentor, she may have missed interpreting this finding, and more generally, she may not have thought beyond the data.

Fourth, focus preservice teachers on a stringent research design. They will learn little about inquiry without a robust design, and will gain valuable insight in both inquiry and educational research with a good design (Lederman & Niess, 1997). Again, preservice elementary teachers have had little, if any, experience in conducting inquiries, thus they will require support. Preservice teachers should conduct a fairly thorough literature review while designing their studies and prior to data collection. Through this process they: gain an appreciation for "what is educational research" from reading others' work (clarifying the difference between systematic research and simply reflecting on practice); clarify their own research questions/problems; and certainly learn what we already know/have established in the

field. While most of our work has been with preservice teachers, one inservice teacher who took a "Teacher as Researcher" methods course stated, "Just reading about all the research related to my study helps me see how my teaching might change." Thus, even the act of reading related research can help teachers see a need and process for change. In our program, the review of literature took place in the research course semester, and required preservice teachers to review at least five outside empirical research sources as backgrounds for their own study. As their work progressed, even through data collection and analysis, most preservice teachers continued to read related research, and modify their literature review. Thus, they spend almost an entire school year reviewing related research, and their final literature reviews are much longer than the original five required.

As part of a stringent research design, preservice teachers should develop carefully a plan for data collection and analysis. This plan may include a timeline for these activities. Even if the students deviate from this plan during the study, having a structure in place helps them to stay focused on their research when the demands of teaching might pull them away. This plan will help them see the nature of scientific inquiry—a plan for investigation that can deviate as the investigation is conducted.

Fifth, preservice teachers need encouragement that they can actually conduct a meaningful inquiry on their science teaching. Again, they are generally quite intimidated about the project especially in the early stages of the design of the study, but continue to need encouragement throughout the study. Beyond the course the preservice teachers take to design their studies, we advocate monthly seminars at which they bring questions, data, problems, or other matters for discussion. These monthly seminars have been approximately one and a half hours in length. The focus is on the preservice teachers' inquiries. The format is informal,

allowing the preservice teachers to raise questions regarding data collection, analysis, and interpretation, and to receive feedback from both their peers and a university researcher. Additionally, the preservice teachers should be encouraged to maintain contact with their university chairs during the entire implementation of their plans.

Finally, we recommend encouraging preservice teachers to disseminate the results of their research. When the preservice teachers recognize that their research can reach a wider audience, they are more determined to design a more stringent plan and more thoroughly examine implications of their findings. They realize that the results of their research can not only benefit them and their own teaching, but also other teachers and teacher educators. This makes the action research a valuable addition to their development as elementary science teachers. It gives them the knowledge that their work is important, and given the fact that other teachers and teacher educators will read their work, could boost their confidence in teaching science.

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